Management and Adoption of Technological Innovations in the Agricultural Sector– With Special Reference to Sugar Cane Industry in Maharashtra and Uttar Pradesh

A

Synopsis

Submitted in the partial fulfillment for the requirement of

Doctor of Philosophy

In

Management

Submitted by

Priya Jayant Khobragade

Under the supervision of

Dr. Purnima Bhatnagar
Co-Supervisor

Professor Shalini Nigam
Supervisor

DEPARTMENT OF MANAGEMENT, FACULTY OF SOCIAL SCIENCES

DAYALBAGH EDUCATIONAL INSTITUTE (DEEMED UNIVERSITY)

DAYALBAGH, AGRA – 282005

2023

SECTION 1

1.1 **Introduction**

Agriculture has long been an essential part of India's economy (Chand R. et al. 2022). After independence, this industry grew rapidly, ensuring that the country transitioned from a food deficit to a food surplus country. This has occurred because of improvements in inputs, innovations, improved infrastructures, and investments by a wide range of stakeholders, including banks and other financial institutions. To make agriculture more productive and to ensure that farmers' incomes increase and have long-term effects on their lives, we need to take a holistic systemic approach (Indian Agriculture Towards 2030, Chand, R., Joshi, P., & Khadka).

Climate change is affecting land, water, and air in many ways - in terms of degraded topsoil, declining groundwater levels, and water contamination increasing greenhouse gas emissions, and reducing biodiversity (Wakchaure et al., 2021). According to oecd.org, agriculture is both a sufferer and a contributor to climate change, and as a result, it must adapt to the effects of the shift and minimize greenhouse gas emissions.

Despite food safety and security, demand and supply shortages, product quality, traceability, etc., the agri-food business contributes significantly to global economic and social improvements. Agri-Food 4.0 focuses on digital innovations in agri-food supply chains (AFSCs). It's very important to emphasize digitization, and mechanization for smart, sustainable agri-food supply chain systems. Mechanization reduces human influence and improves data accuracy. Uncertainty/fear of failure and cost are some of the major issues associated with the mechanization of farms and agriculture sector in general.

The United Nations' SDGs (Sustainable Development Goals) have been endorsed by India as a global appeal to alter the world by 2030. As a result, the SDG India Index was released in December 2018, recognizing the need to change climate as a major reality. Climate change and new challenges facing global food systems will require agriculture to adapt and respond appropriately (oecd.org).

In the face of extreme climate events, such as acute and frequent droughts, floods, and extreme heat, are becoming more common (Wakchaure et al., 2021), as rainfall patterns have already begun shifting across the country, and such changes are expected to intensify over the coming years. When summer

heat intensifies, workers and crops face extreme situations and crop yield failure. The misery in many rural areas will also worsen because of failing farms and stagnant farm revenues. Mechanization and adoption of innovations is required to enhance agriculture and crop yield. Major challenges reported by many are uncertainty, fear of failure, and financial ramifications etc.

1.2 Concept of Innovation:

Some of the famous definitions of innovation:

- Rogers (1983) referred to the innovation "as an idea, method, or practice that the individual perceives as a new thing or a new idea".
- Barack Obama stated that "Innovation is something fresh (new, original, or improved) that creates value".
- According to OECD (Organization for Economic Co-operation and Development) manual "An innovation is a new or improved product or process that differs from the previous products or processes".
- According to the European Commission, EIP-AGRI, "Innovation is a new idea that proves successful in practice**".** In other words, innovation might be technological, non-technological, organizational, or social and based on new or conventional techniques. A new concept can be a new product, practice, service, production process, etc.
- According to José Graziano da Silva FAO Director-General - "Innovation is fundamental to supporting family farmers, revitalizing rural areas, creating attractive job opportunities for youth, bringing prosperity to communities as a whole, and helping achieve the Zero Hunger world we want".

Hence, we can say that there is no single, universally accepted definition of innovation, however:

"An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users or brought into use by the unit (process)".

"A business innovation is a new or improved product or business process that differs significantly from the firm's previous products that has been introduced on the market or brought into use by the firm."

The Oslo Manual Innovation lists four types of innovations: product innovation, process innovation, marketing innovation, and organizational innovation.

Product innovation is when a good or service is new or has been improved in a big way. This includes making big changes to the product's technical aspects, its parts and materials, its software, how easy it is to use, or how it works in other ways.

Marketing innovation is a new way to sell a product that involves making big changes to its design, packaging, placement, promotion, or price.

Organizational innovation is a new way to run a business, organize a workplace, or deal with the outside world.

Process innovation is a new or significantly better way to make something or get it to someone. This includes changes to techniques, tools, and/or software that are big.

1.3**. Agricultural Innovation:**

Agricultural innovations are mainly concerned with a need for increasing production (of food, fodder, secondary products etc.) as well as enhancing quality (of produce, production process, growing conditions) (van der Veen, M. (2010). Agricultural innovation means ideas, knowledge, attitudes, intentions, decisions, and the ability to accept new things including new practices by the farmers (Wongwai, K., Kamarulzaman, N. H., Wong, K. S., & Ali, F. (2021).

At the farm level, there are many "process innovations" that improve production techniques, such as high yielding seeds, improved irrigation systems, or breakthrough technologies to double the profits of marginalized farmers in developing countries as well as increase food productivity while protecting the ever-degrading environment (Urabe, 1988).

Agriculture GDP in India fell from 4862.92 INR billion in the second quarter of 2021 to 4076.41 INR billion in the third quarter of 2021 (Source: Ministry of Statistics and Programme Implementation (MOSPI)). Agricultural innovations, like agricultural technology, can be used to promote an innovation to farmers, and once implemented, they become a technology.

1.4. **Adoption of Technology:**

The slow adoption of technology has always been the most significant impediment to increasing farm productivity, income, and yields. Adoption of appropriate technology in agriculture is critical for

increasing productivity. Many research papers show that adoption of externally promoted technologies remains low, with adoption moving at a slow pace among small-scale farmers in developing countries (Amare and Darr, 2020, Dadi et al; 2004; Deressa et al., 2009; Doss, 2006; Douthwaite et al., 2001; Feder et al., 1985; Foster and Rosenzweig, 2010; Ghadim and Pannell, 1999; Greenhalgh et al., 2019; Johnson et al., 2016; Meijer et al., 2015; Mica, 2013). With the adoption of better technologies agri-food producers must provide safe, secure food for all, so it is critical to adopt new technologies to ensure effective process management. There are many important stakeholders in the agriculture ecosystem.

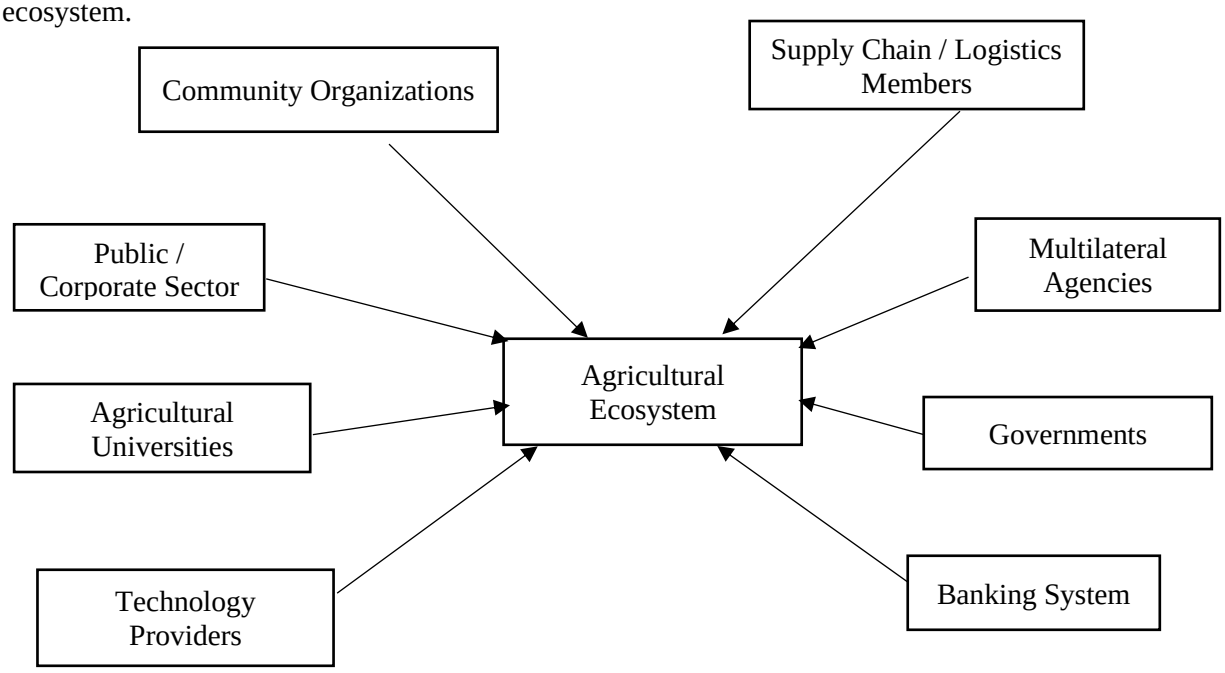

Figure 1: **Stakeholders of Agricultural Ecosystem (Researcher's Compilation)**

Table 1: Definitions of Agricultural Ecosystem

S.No.	Explanation	Definition	Reference
1.	Agricultural Management	Agricultural management has a significant impact on the processes and functions of soil. Crop yield is influenced by agricultural management strategies.	Techen, A. K., Helming, K., Brüggemann, N., Veldkamp, E., Reinhold-Hurek, B., Lorenz, M., ... & Vogel, H. J. (2020).
2.	Technology Adoption	Technology adoption is a step of deciding how to use a technology by an individual or an organization. With rapid advancements in technology in all industries, challenges around technology adoption have increased.	Carr, (1999)

3.	Stake Holders	Stakeholders are individuals (or organizations) who can either influence or be influenced in the decision-making process.	Brugha, R., & Varvasovszky, Z. (2000)
4.	Government Interventions	The appropriate role of government in any industry.	Jaccard, M. (1995)
5.	Farmers Perception	The farmer's perception is farmers understanding of organic farming and issues associated with it. It is based on their demographic characteristics, risk taking abilities, crops which they grow, present source of information and attitudes etc.	Patidar, S., & Patidar, H. (2015)
6.	Perceived Usefulness	The extent to which a person believes that implementing a specific system will improve his or her job performance.	Davis, F. D. (1989).
7.	Perceived ease of use	The degree to which a person believes that using a particular system would be free of effort.	(Rogers, 2003)
8.	Multilateral Agencies	A Multilateral Agency is an international organization made Multilateral agencies provide loans and guarantees for investments that are in line with their development goals. The United Nations, the World Bank, and the Asian Development Bank, for example, are multilateral institutions or agencies.	King, K. (2007)

1.5 Sugar cane production in India

Sugar cane has been recognized as an important cash crop. Sugar industry is one of the most important agro-based industries in India. India is the second largest producer of cane sugar after Brazil. India's sugar consumption in the year 2021/2022, is expected to increase by nearly 3% from the previous year to an all-time high of 27.2 million tonnes (ISMA). According to the Indian Sugar Mills Association, April 2022, India is expected to export around 4-6 million tonnes this year (Sugar Report, 2022). The government intends to blend 20% ethanol into gasoline by 2025, up from 10% currently.

Table 2. Structure of sugar mills in India.

Sector	**Public sector**	**Private Sector**	**Cooperative Sector**
Number of sugar mills	43	362	327
Percentage	5.88%	49.45%	44.67%

1.2.1 Role of technology in Indian sugar cane farms

Sugarcane is the country's most important commercial crop, covering 5.2 million hectares in India. New income-generating opportunities must be created through crop diversification. Changes in the

market, consumer tastes, and global competition mean that new ways to make money must be found. Crop diversification and sugarcane in the produce-to-product chain are two ways to do this (Bhingardeve et al, 2018). The Government of India has proposed doubling farmers' income in the next five years. (http://www.krishijagran.com/news/government-seven-point-strategy-for-doubling-farmers-income/&hl=en-IN). The specific goal of increasing sugarcane farmers' income could be met by developing cost-effective technologies, transferring them from the laboratory to the field, educating the farmers, and establishing a link between all stakeholders (Singh et al, 2019). The slow adoption of technology has always been the most significant impediment to increasing farm productivity, income, and yields.

Adoption of appropriate technology in agriculture is critical for increasing productivity. Adoption of externally promoted technologies remains low, with adoption moving at a slow pace among small-scale farmers in developing countries. Small and dispersed land holdings reduce scale advantages thus pose a significant barrier to further farm mechanization expansion in India. Small and dispersed land holdings reduce scale advantages thus pose a significant barrier to farm mechanization expansion in India.

Technical Adoption Model (Fred D Davis, 1989)

- In technology adoption research, the Technology Adoption Model (TAM) has been widely used.
- The model is very simple, as it only contains two main components for predicting the extent of adoption of new technologies at the individual level, namely "perceived usefulness" and "perceived ease of use," as shown below.

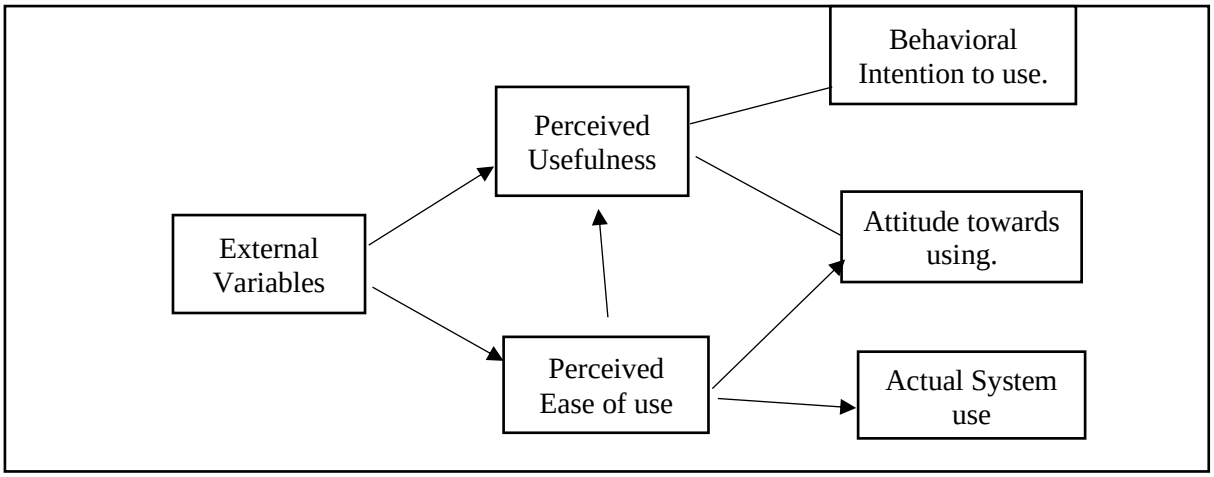

Figure 2: **Technology Adoption Model – Researcher's Compilation**

1.2.2 The present scenario of technology in sugar cane farms in India

Farm mechanization has the potential to increase agricultural productivity by 30% while lowering input costs by 20% (NABARD, 2018). Mechanized farming also shortens the time required to complete farm operations and alleviates the problems that are inherently associated with agricultural labor. International comparisons show that India has much lower levels of farm mechanization than other advanced economies and BRIC countries (Mukherjee et al, 2022). To increase cane and sugar productivity, sustained efforts, and a holistic approach to the integration of multiple sugarcane production technologies are necessary. As a result, the sugarcane-based agricultural populace's income will rise, and the Government of India's goal of doubling farmers' income by 2022–23 would be met (Singh, et al, 2019, *3 Biotech*, *9*(2), 1-15).

Sub Mission of Agricultural Mechanization 2020-2021: According to the government initiatives on farm mechanization the Indian government has launched many projects and programmes. A few subsidy schemes that benefit farmers who own the requisite machinery are listed below:

- **Paramparagat Krishi Vikas Yojana (PKVY)** - This scheme is launched in 2015 and is an elaborate component of Soil Health Management (SHM) of major project National Mission of Sustainable Agriculture (NMSA). The goal of the Paramparagat Krishi Vikas Yojana is to plan sustainable, organically certified farmlands and give farmers more power.
- **Rashtriya Krishi Vikas Yojna (RKVY) -** This scheme was started in 2007 as an overarching plan to help agriculture and other related sectors grow in all ways. The scheme gives States an incentive to put more public money into Agriculture and related fields.
- **National Forestry Service Mission (NFSM) -**At its 53rd meeting on May 29, 2007, the National Development Council (NDC) voted to start a Food Security Mission for rice, wheat, pulses, and sugar.
- **National Horticulture Mission (NHM) -** In 2005-06, the National Horticulture Mission was started as a Centrally Sponsored Scheme to promote the growth of the horticulture industry by using different strategies for each area. This programme is meant to boost horticulture production, improve food security, and help farm families make more money.

- **Gramin Scheme on Promotion of Bhandaran Yojana (GBY -** Gramin Bhandaran Yojana is a 2001 capital investment subsidy scheme for rural godowns. Godowns should be outside municipal bounds.
- **Yantra Laxmi Scheme** - It is farm Mechanization Scheme which will provide a 50% subsidy and a 50% loan for tractors and farm equipment. The programme is run by the Agricultural Mechanization Centre.

1.3.1 Crop management & The complexity of problem

Sugar cane procurement from farms has a lot of potential for meeting rising demand, so it's an opportunity, but it also comes with a lot of challenges for small, marginal, and medium-scale farmers (Rangnekar, 2001). Across the country, there are many well-established farms. Some are succeeding, while the majority are struggling. The main cause of underperformance is land degradation, crop residue burning and supply chain unit management problems (Bordonal, 2018). Previous studies have shown that technology intervention can increase the efficiency of farm operations (Janssen, 2017), as technology is one of the major driving factors for improving operational efficiency in the industry (Subburaj, et al, 2015; Quddus, 2012). In addition, certain entry-level enabling factors (Akkeren, 1999) exist for technology adoption, with possible implementation and maintenance-related challenges acting as roadblocks to achieving the value.

Some of the major challenges include difficulty in getting sugarcane setts, lack of capital for sugarcane cultivation, lack of modern sugarcane processing machineries in sugar mills, awareness, lack of mechanical fertilizer deep placement machines, weeding & tilling problems along with technical and management assistance, skills, and so on.

1.3.2 Pilot Study:

Researcher conducted pilot study in specific sugar mills of Maharashtra and Uttar Pradesh and came to know about the problems faced by sugar mills, stake holders and most importantly farmers. Pilot study was done with 24 farmers in three sugar mills. They shared their experiences and problems facing in the mechanization and adoption of technological innovations in sugarcane industry. They shared that they want to adopt new technologies but due to subsidy portals not opening in time they are unable to buy urea deep placement machines, which can help in reducing wastage of urea and other fertilizers.

As conventional method of urea broadcasting leads to 70% wastage and pollutes the environment too. Tested Urea Deep Placement machine whereas it reduces use of urea by 40% and increases the yield of crop as crop health and resistance is significantly improved.

Visited these sugar mills:

Uttar Pradesh: Hardoi– DCM Sugar mills at Loni, Ajbapur.

**Maharashtra: Bhimashankar Sahkari Sakhar Kharkhana, Amrutnagar,

Someshwar Sakhari sakhar Kharkhana, Baramati

SECTION 2

2.1 REVIEW OF LITERATURE

The purpose of the literature review for the proposed research is to gain a better understanding of the fundamental concepts and insights of sugarcane farms, crop management as well as agricultural innovations in India and abroad. The reviewed literature comprises of 37 papers that focused on agricultural innovation & technology adoption, revamping the supply chain practices and management, farm mechanization, industry analysis as changing fertilizer management practices in sugarcane production, sugarcane based intercropping system etc. Most of the papers highlighted the issues and the challenges related to operational inefficiency in the agricultural sector.

There were 20 papers and articles related to innovation & technology adoption in sugarcane farms. 12 papers were related to the innovations in the Agri food sector, and others were related with technology adoption, crop management, and implementation of it in sugarcane farms (Dadi, Nikhil, et al 2021). There were 3 papers and articles related to supply chain management in sugarcane industry. There were several factors that affect technology adoption. These challenges may be related to cost, capability, awareness, resources, infrastructure, etc. (Patel, 2017). Most of the sectors have some or the combination of these challenges. The results indicate many challenges are basically, high initial cost, high fuel cost, lack of credit facilities, small land pieces, non-availability of service centers and spare parts, wastage during harvest, along with wastage of fertilizer and bad soil quality etc. (Madhukar et al, 2021).

There were 14 papers related to industry analysis. In that at global level, some papers were directly related to industry analysis with special mention to “Barriers to the adoption of circular economy in

the Brazilian sugarcane ethanol sector". Brazil produces a lot of sugarcane and ethanol, which contributes to the renewable energy sector.

However, few studies show that the sugarcane ethanol sector has adopted the circular economy (Jugend, 2021). Due to high crop investments and uncertainty in crop results and yield, the main barriers are financial and economic (Jugend, 2021). A reliable assessment of sugarcane crop production is necessary to identify the most important targets and effective strategies to improve its environmental and economic outputs (Yang Linsheng, 2022). While the technology focused approach helped India to meet its food security requirements by reducing cereal imports, the long-term consequences are now visible in terms of degraded topsoil, declining groundwater levels, and water contamination increasing greenhouse gas emissions, and reducing biodiversity in the face of extreme climate events, such as acute and frequent droughts, floods, and extreme heat, are becoming more common (Wakchaure et al., 2021). Lack of coordination, disruptions in raw material supply due to natural disasters, and other issues hamper the growth in sugar industries. Industry requires efficient supply chain management to address all these issues (Dhande, Nishikant et al., 2012) and better technologies to enhance the production of sugarcane.

Classification of Literature Review

1. **Focus of the paper**
    a. Innovation & Technology adoption by farmers, stake holders – 18 papers
    b. Industry Analysis of the industry understudy – 14 papers
    c. Crop Supply Chain Management – 3
2. **Context of the paper**
    a. Foreign – 24 b. Indian – 11
3. **Type of Data for analysis**
    a. Qualitative b. Quantitative
4. **Research Design**
    a. Exploratory b. Descriptive c. Analytical d. Empirical

Summary of Literature Review													
Title ***Author(s) (Year)***	**Category**	**Year of Publication**	**Focus Issue**			**Context**		**Data Type**		**Methodology**			
			Supply Chain Management	**Innovation & Technology Adoption Technology adoption**	**Industry Analysis**	**Indian**	**Foreign**	**Qualitative**	**Quantitative**	**Empirical**	**Descriptive**	**Analytical**	**Exploratory**
Factors Influencing Small Farmers to Participate in Sugarcane Loading stations in THAILAND, Wongwai, K., Kamarulzaman, N. H., Wong, K. S., & Ali, F.	Article	Mar 2021			✓		✓		✓		✓	✓	
Research and development challenges in scaling innovation: a case study of the LEAP-Agri RAMSES II project Seghieri, J., Brouwers, J., Bidou, JE. et al.	Research paper	Aug 2020		✓			✓		✓	✓			
Farmers' perceptions and issue of Kredit Usaha Rakyat in Indonesia Gunawan, E., Ilham, N., Syukur, M., Pasaribu, S. M., & Suhartini, S. H. (2021, November)	Research Article	Jan 2021			✓		✓	✓			✓	✓	
Challenges of agri-food supply in city region food systems: an emerging economy perspective,	Research Paper	May 2021	✓				✓	✓					

Weerabahu, S.K. et al													
Reconciling productivity, profitability, and sustainability of small-holder sugarcane farms: A combined life cycle and data envelopment analysis. Yang, Linsheng & Zhou, Yifan & Meng, Bo & Li, et al	Article	Mar 2022			✓		✓		✓		✓	✓	
Transforming Indian Agriculture, Gulati Ashok, Juneja Ritika	Book	Mar 2022			✓	✓			✓		✓		
Agri-food sector and entrepreneurship during the COVID-19 crisis: A systematic literature review and research agenda, Apostolopoulos, Nikolaos & Ratten, Vanessa & Petropoulos, Dimitrios & Liargovas, Panagiotis & Anastasopoulou, Eleni.	Research Paper	July 2020			✓		✓	✓			✓		
Constraints in adoption of farm mechanization and suggestions to overcome the constraints, Madhukar, Reddy, T Lakshmi, and Y Reddi Ramu	Research Article	May 2021		✓		✓			✓	✓			
Barriers to adopting new technologies within rural small and medium enterprises, Fanelli, Rosa.	Article	June 2021		✓			✓		✓		✓	✓	
RHS, Inc.: Innovation "Guiding" Agriculture, Schenkel, M. T., Finley, J., & Chumney, W	Education Review	Mar 2021		✓			✓	✓			✓		

Problem Confrontation of sugarcane farmers in Nathore district of Bangladesh, Hoque, M. J., Hossain, M. I., Sarker, M. A., & Mithun, M. N. A. S.	Research Paper	June 2021			✓		✓		✓		✓	✓	
The distribution of roles and functions for upscaling and outscaling innovations in agricultural innovation systems, Hermans, F., Stuiver, M., Beers, P. J., & Kok, K.	Original Paper	June 2013		✓			✓	✓		✓		✓	
Integration of sugarcane production technologies for enhanced cane and sugar productivity targeting to increase farmers' income: strategies and prospects, Singh, P., Singh, S. N., Tiwari, A. K., Pathak, S. K., Singh, A. K., Srivastava, S., & Mohan, N.	Research Article	June 2019		✓		✓		✓					✓
Supply chain management in Sugar Industry: A study of western Maharashtra, Dhande, Nishikant & Salkute, Vijaykumar.	Article	Sept 2012	✓			✓		✓			✓		
Sugarcane based intercropping system and its effect on cane yield, Geetha, P., Sivaraman, K., Tayade, A. S., & Dhanapal, R.	Research Paper	July 2017			✓	✓		✓			✓		
Changing Fertilizer Management Practices in Sugarcane Production: Cane Grower Survey Insights (Farm management), Hasan, S.; Smart, J.C.R et al.	Research paper	Jan 2021			✓		✓	✓		✓	✓		

Indian Agriculture counting on Farm Mechanization, Mehta, C. & Chandel, Narendra & Jena, Prakash & Jha, Anamika	Article	Jan 2019		✓		✓		✓				✓	
Farm Mechanization in Bangladesh: A review of the status, roles policy and potential, Rahman, M. M., Ali, M. R., Oliver, M. M. H., Hanif, M. A., Uddin, M. Z., Saha, K. K., ... & Moniruzzaman, M. (2021)	General Review	Jan 2021		✓			✓		✓		✓	✓	
Knowledge and Adoption of Intercrop in Sugarcane from Kolhapur District, Bhingardeve, S. D., Tarde	Case Study	Jan 2018		✓		✓		✓			✓		

2.2 Summary of Research gap: Indian perspective

India's agricultural economy relies on sugarcane and sugar as trade and livelihood commodities. It affects the lives of over 5 crore farmers and their dependents who grow sugarcane on nearly 50 lakh hectares. Moreover, the sugar industry directly employs 5 lakh people and indirectly employs 10 lakh people (Source: Sugar report, Niti Aayog, March 2020). Sugarcane is used as a raw material to make sugar, biofuels, and bioproducts (Rumankova et al. 2013; OECD-FAO, 2019). Sugarcane production is hampered by a complex system of, weather, land degradation, crop residue and fertilizer management along with pricing, supply, and regulations (Source: Sugar Report, Niti Aayog, March 2020). Sugarcane and sugar are both essential commodities, regulated by the Essential Commodities Act of 1955. To put it another way, sugarcane cultivation land, sugarcane prices and sugar mill sales on both the domestic and international markets are all strictly regulated.

1. For environmental and economic reasons, the global search for alternate fuels for energy has increased. Biomass is one of the most important renewable resources. Ethanol, bagasse, and harvesting residue are also the common products obtained from sugarcane as potential alternative energy sources. How it can be used properly it has to be researched on in Indian context. Union Minister Nitin Gadkari has stressed on 4th June 2022 that India needs to switch to alternative fuels, he has said that efforts are on to launch ethanol in construction and agriculture equipment. While speaking at a conference in Pune the minister said that alternative fuels is the future of India.
2. Sugar cane has a manpower concern. Where weeding, tilling, and earthing up along with fertilizers and inter-culturing operations is a very important aspect of this industry. Major changes in fertilizer management of sugar cane industry are required to investigate. Despite notable progress in mechanizing tillage activities, research reveals that other areas which have yet to be mechanized are fertilizer dispersion, weeding and earthing up etc. (Rahman, M. M., Ali et al, 2021).
3. Intercropping is also an area of agricultural research that is still not properly understood. It is important to study the impact of a sugarcane-based intercropping system on cane yield that will enhance the farmer’s income. More research is needed to better understand how intercrops

function and to develop intercropping systems and to understand the effect of intercropping system on sugarcane yield (Geetha, Sivaraman, et al 2015).

4. Fourthly, the trend of sugar farms and the productivity of the existing farms is a major concern, where the supply chain management and other factors affect the product. Need to see how to have better supply chain management practices in sugar cane industry. Uttar Pradesh has many private sugar mill owners whereas some sugar mills are owned by the farmers collectively whereas Maharashtra has cooperative sugar mills.

For doubling the farmer's income, we need to improve agricultural technology, use present expertise to improve farming processes, and reduce fertilizer use, water, and other input waste. The evidence from globally existing farms indicates that with technological intervention, the productivity of sugarcane farms and doubling income of farmers management can be tackled efficiently.

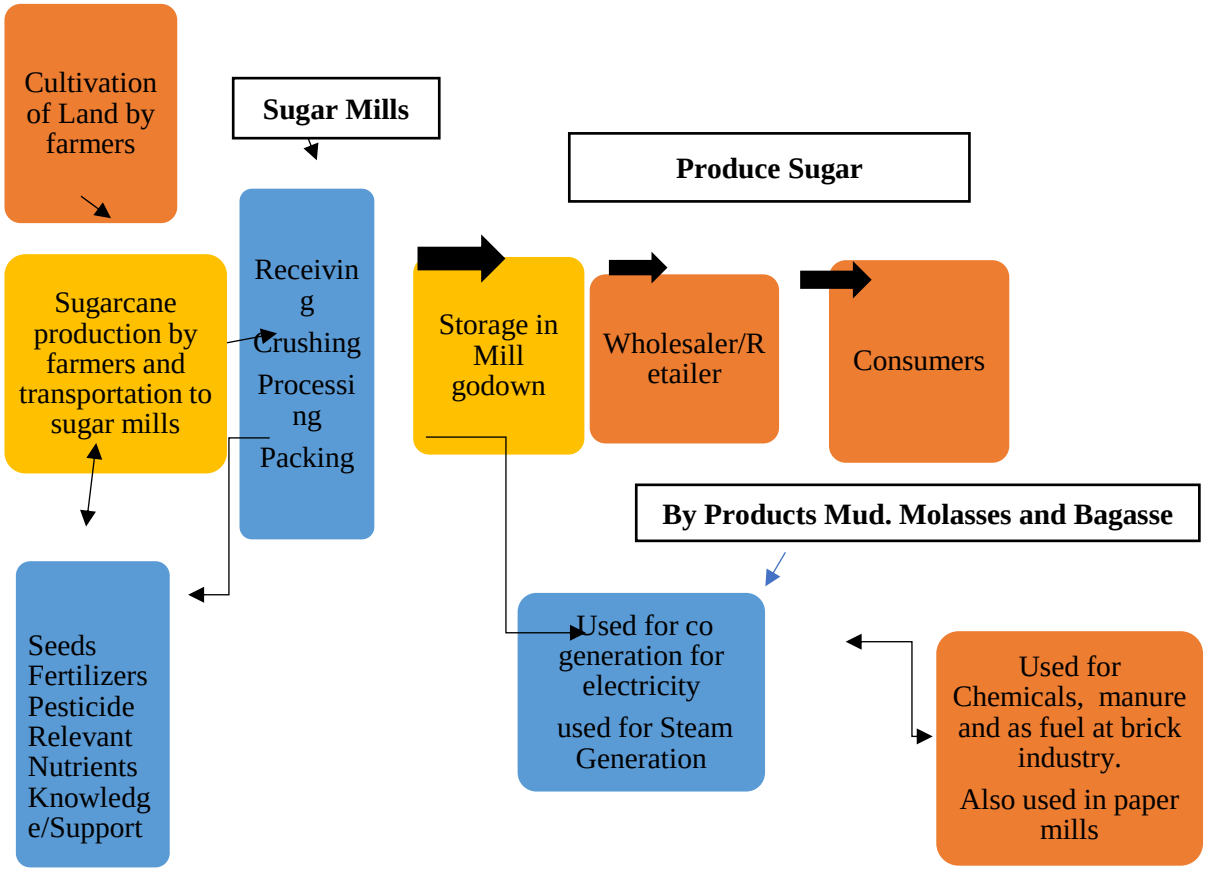

Figure 3: **Sugar Supply Chain Management: An approach from farmers to sugar mills** (Researcher's Compilation)

SECTION 3

3.1 CONCEPTUAL FRAMEWORK

To bridge the technology gap, a study is needed to analyze the leading technologies in the area and the adoption behavior of sugarcane producers (Karpagam, C. et al, 2019). In farm operations, technology adoption, managerial practices, and production systems all play a catalytic role (Gillespie et al, 2014). Using technology to improve farms' performance and production is referred to as strategic planning.

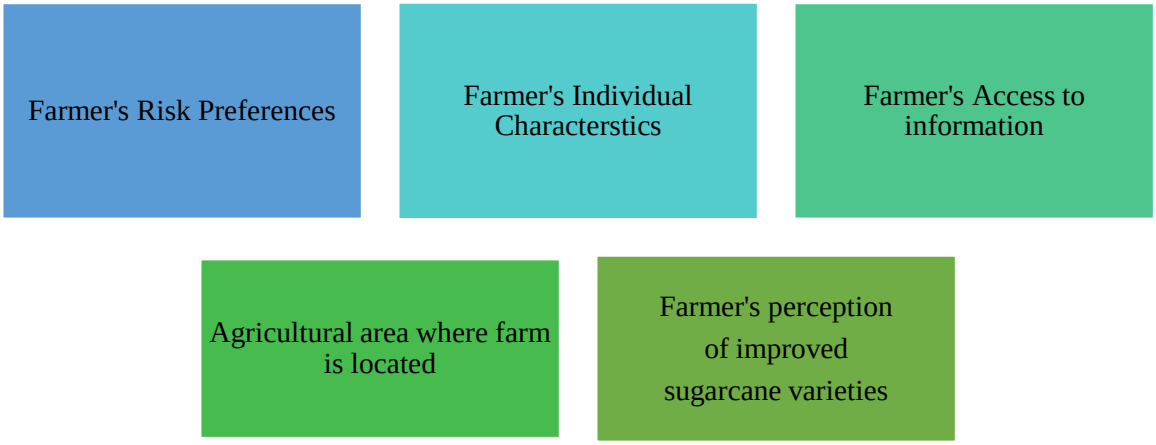
Farmer's Risk Preferences
Farmer's Individual Characterstics
Farmer's Access to information
Agricultural area where farm is located
Farmer's perception of improved sugarcane varieties

Figure 4 - All factors affect adoption of improved sugar cane technology–Researcher's Compilation

Farmers who are progressive, young, and educated are some of the factors that influence the adoption of new technologies. Despite this, not all farmers adopt recently developed technologies because they have different risk preferences, perception and are from different agricultural areas. Apart from this, access to information and trust in newly developed technologies are some of the factors that influence farmers' adoption of new and improved technology. They don't want to use new technology or sugarcane varieties because they don't think it will guarantee a high yield, which makes them feel uneasy.

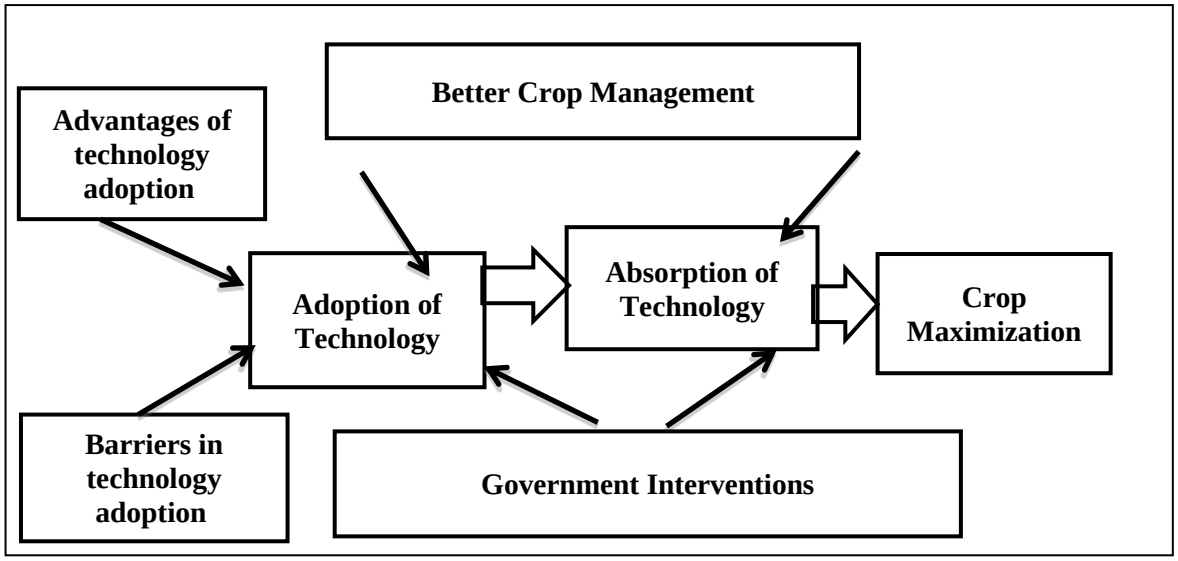

Figure 5. Conceptual Framework (Researcher's Compilation)

In farm operations, technology adoption, managerial practices, and production systems all play a catalytic role (Gillespie et al, 2014). Using technology to improve farms performance and production is referred to as strategic planning (Susanty et al, 2017).

3.2 Advantages and Barriers for technology adoption:

There are several enabling or driving forces that are necessitated for any type of adoption. For example, technology adoption may be aided by factors such as ease of use, cost-effective technology, availability, perceived value, government rules, legislation, and policies, etc. Technology adoption in any sector is not a one-day effort due to the numerous hurdles that come with such a significant change (Chatzoglou, et al, 2016). The Indian sugarcane sector has numerous challenges in various areas.

The way consumers feel about technology is also an important thing to think about (Millar et al, 2002). Other studies by Ghadge et al (2017) and Joshi et al (2009) have shown that small and medium-sized farms have a lot of problems because of factors like lack of money, lack of technical knowledge and help, lack of literacy, lack of infrastructure, electricity and water, lack of land, etc.

In addition to these factors, researcher will also look at other factors that affect how small and medium-sized sugarcane farms use technology.

3.3 Problem Statement

Sugar cane procurement from farms has a lot of potential for meeting rising demand, so it's an opportunity, but it also comes with a lot of challenges for small, marginal, and medium-scale farmers (Rangnekar, 2001). Across the country, there are many well-established farms. Some are succeeding, while the majority are struggling. The main cause of underperformance is land degradation, crop residue burning and supply chain unit management problems (Bordonal, 2018).

The Government of India has slated the idea of doubling farmers' income in the next five years. The target of increasing sugarcane farmers' income could be met by developing cost-effective technologies, transferring them from the laboratory to the field, educating the farmers, establishing links among all stakeholders.

The current study tries to fill the gap. This study will involve farmers, sugar mill management, different stake holders, and policy makers to provide a more unified and holistic approach to technology adoption for better sugarcane cultivation. The following factors were identified from the literature review and will be investigated further.

1. Ease of accessibility of technology
2. Farmer’s different characteristics
3. Lack of education and understanding
4. Different agricultural zone
5. Farmer’s perception
6. Lack of capital for technology adoption
7. Problems in getting subsidies.
8. Positive word of mouth

3.4 Objectives of the study

The objectives of this research are:

- Objective 1: To study present status and process of management and adoption of technological innovations in sugarcane industry.
- Objective 2**:** To identify the barriers in adoption of technological innovations in sugar cane industry.

- Objective 3: To study the impact of government interventions for sugar cane industry.
- Objective 4: To study the impact of technology adoption for doubling the profit of marginalized farmers.

3.5 Hypotheses:

- **Ha1**: Farmer's awareness of technology has positive effect on technological adoption.
- **Ha2**. The present status of technology adoption has positive effect on technology adoption.
- **Ha3:** A lack of subsidy has a negative effect on the adoption of agricultural innovations.

SECTION 4

4.1 RESEARCH METHODOLOGY:

4.1.1 Scope of Study:

To bridge the technology gap, a study is needed to analyze the leading technologies in the area and the adoption behavior of sugarcane producers. With that in mind, a study is to be undertaken with the goals of analyzing mechanization and technological mapping and studying sugarcane producers' adoption behavior along with supply chain management in sugar cane industry.

- **4.1.2 Research Design:** The research undertaken in this study is analytical and descriptive in nature.
- To meet the objectives of this research it is important that the sugarcane farms and sugar mills be contacted for use of appropriate management and adoption of technological innovations in sugar cane industry.
- **4.1.3 Selection of states** by researcher are selective cities and sugar mills of Maharashtra & Uttar Pradesh. As these states have big clusters of sugarcane fields in India and are the leading sugarcane producers.
- **Maharashtra produces 20% of India's sugar, with Uttar Pradesh accounting for 24% of India's sugar production. (Source: Financial Express, April 2022).**
- **4.1.4** Respondents: Farmers, sugar mill management, stake holders, policy makers etc.

- **Table 3**: **State-Wise Area under Sugarcane Cultivation ('000 Hectares)**

States	2014-15	2015-16	2016-17	2017-2018	2018-2019	2019-2020	2020-2021
Andhra Pradesh	139.0	122.0	103.0	99.0	102.0	86.0	55.0

Bihar	254.3	244.0	239.6	236.2	226.0	224.0	219.0
Haryana	97.0	93.0	102.0	114.0	109.0	96.0	99.0
Karnataka	480.0	450.0	397.0	350.0	471.0	429.0	443.0
Maharashtra	1030.0	987.0	633.3	902.0	1163	822.0	1143.0
Punjab	94.0	90.0	88.0	96.0	95.0	91.0	89.0
Tamil Nādu	263.1	252.3	218.3	179.7	166.0	131.0	125.0
Uttar Pradesh (U.P)	2141	2169	2160	2234	2224.0	2208.0	2180
Uttarakhand	101.7	96.9	93.0	90.0	91.0	92.0	84.0
Rest of India	455.9	423.0	401.6	431.1	414.0	424.0	316.0
All India	**5056**	**4927**	**4436**	**4732**	**5061**	**4603**	**4753**

Source: Directorate of Economics and Statistics, Ministry of Agriculture and Farmers' Welfare & *Source - E&S, DAC, New Delhi, * 4 th Adv. Est.-2020-21

- The highest amount of sugarcane in India is produced in Uttar Pradesh, which accounts for 24% of the nation's sugar production. While Maharashtra is India's second-largest producer of sugar cane in India (Source: Financial Express, April 2022).
- **4.1.5 Sampling Frame:** The sampling frame for the proposed research is the listing of the respondents in the age bracket of 18-60+ years.
- **4.1.6 Multistage Sampling will be used:**
- 2 Clusters: Pune District in Maharashtra and Hardoi District in Uttar Pradesh will be taken. Mills will be selected based on judgemental sampling.
- Then Farmers will be selected based on random sampling attached to these mills.
- The Slovin's formula can be used here for multistage sampling based on scenarios. It is as follows:
- n-N/(1+Ne2), where
- n=The sample size
- N=The population size (9973)
- e=The margin of error (0.05%)
- As 95% confidence level is taken.
- Example: n=9973/ (1+9973*(0.05)2) =9973/25.9325 =**384.5747= 384 sample size**

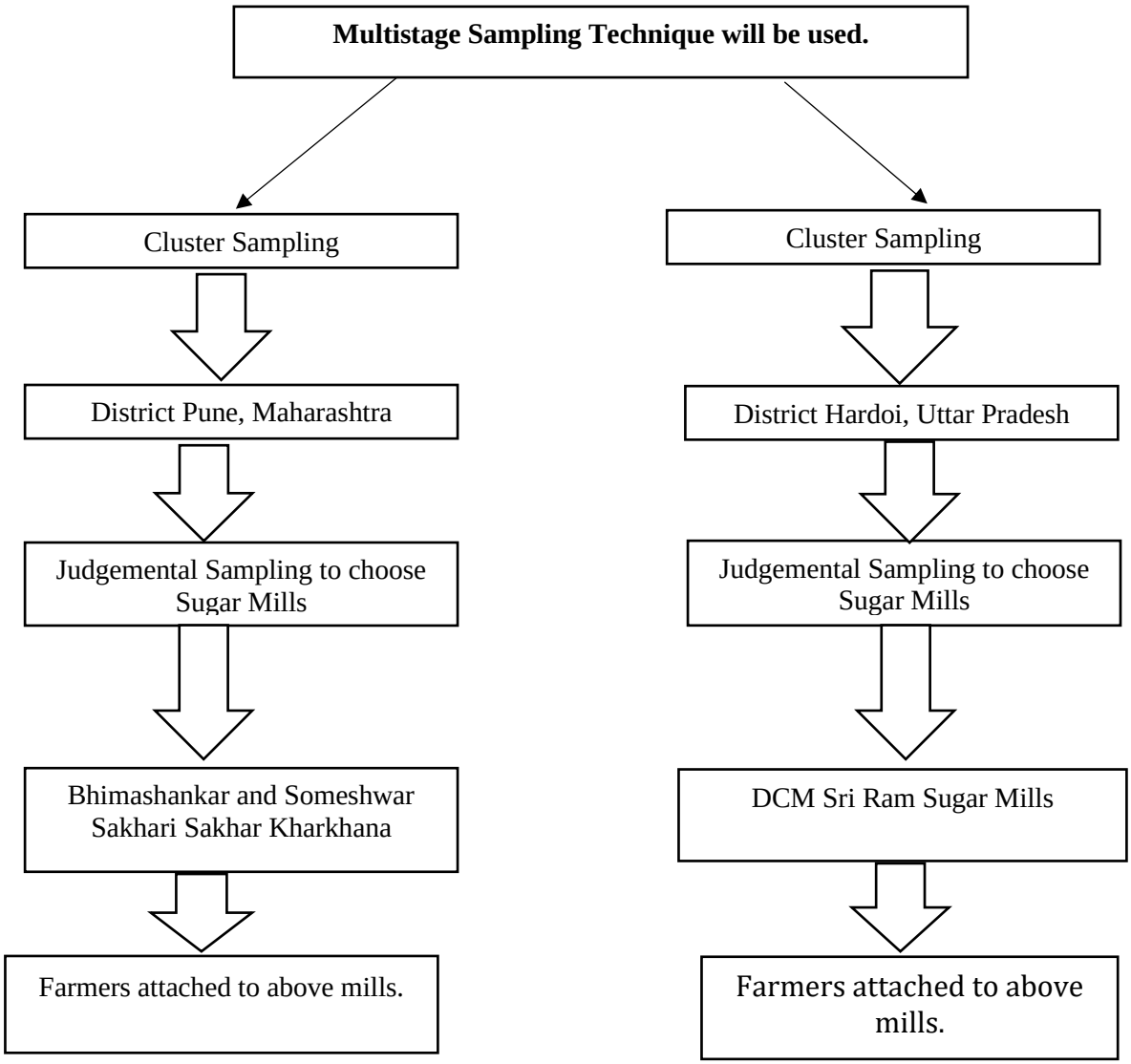
Multistage Sampling Technique will be used.
Cluster Sampling
Cluster Sampling
District Pune, Maharashtra
District Hardoi, Uttar Pradesh
Judgemental Sampling to choose Sugar Mills
Judgemental Sampling to choose Sugar Mills
Bhimashankar and Someshwar Sakhari Sakhar Kharkhana
DCM Sri Ram Sugar Mills
Farmers attached to above mills.
Farmers attached to above mills.

Figure 6: <u>Multistage sampling- (Researcher's compilation)</u>

For this study, the proposed research will have this sample plan:

*Uttar Pradesh: Hardoi and Lakhimpur District – DCM Sugar mills at Loni, Ajbapur, Hariawan sugar mills

**Maharashtra: Bhimashankar Sahkari Sakhar Kharkhana, Amrutnagar, Someshwar Sakhari sakhar Kharkhana, Baramati

4.2 Data Collection and Data Analysis

4.2.1 Primary Data: Self-structured questionnaire / interviews/ survey/ observation techniques / schedule etc. will be used to collect primary data.

4.2.2 Secondary Data: (Proposed**)** Annual reports issued by Sakhar sankul, websites, Indian Institute

of Sugarcane Research reports**,** Niti Aayog's reports, journals, books, various research papers etc. These will be analyzed in the view of technology adoption status in sugar cane industry, mechanization, management of supply chain etc.

4.2.3 Tools and techniques to be used.

Descriptive Statistics, ANOVA, t-test, Z test, Regression, and Correlation would be used for data analysis. Appropriate tools & techniques will be used.

4.2.4. Table 4.: Data Collection from Stakeholders of Agriculture Ecosystem from Maharashtra and Uttar Pradesh (Tentative)

S. No.	Stakeholders	Mode of Data Collection	Tentative numbers to be contacted	Percentage (from 384 sample size)
1.	Multilateral Agencies (implication of innovations)	Survey	14	3.65%
2.	Agriculture University (innovation and R&D)	Interview/Survey	2	0.52%
3.	Government (District Magistrate, District Agriculture officer, Chief Development Officer	Interview	16	4.17%
4.	Mill Management (General Manager Cane, In charge Soil Laboratory, Agriculture officer etc.)	Observation / Interview/ Survey	20	5.22%
5.	Banking System (NABARD and other loan providing agencies)	Survey	12	3.13%
6.	Public Sector (Commissioner Sugar, Director Sugar etc.)	Interview / Questionnaire	10	2.60%
7.	Supply chain / logistics members (Dy General Manager Cane, Mill officers, workers etc.)	Interview	26	6.77%

8.	Technology Providers (Director of company, Managers, Field officers etc.)	Schedule / Interview/Survey	15	3.91%
9.	Farmers based on 0 to 2 acres land 2 to 10 acres land 10 to 20 acres land 20-100 acres land	Interview/Survey/Observation	 78 65 56 70	 20.31% 16.92% 14.58% 18.22% 100%

Managerial Implications:

It is estimated that after completion of this research, researcher will be able to conclude that the findings have several implications for adoption and management of technological innovations for sugarcane cultivation.

- It will help to adopt technology to double the profits of marginalized farmers across the developing world and increase food production while protecting the ever-degrading environment.
- Considering the economically difficult times that many farmers and sugar mills are currently facing, it may be wise for them to focus on adoption and farm mechanization in the country as per the schemes of government.

SECTION 5

PROPOSED CHAPTERIZATION

The proposed research will contain the following chapters:

- Introduction
- Theoretical framework and Literature Review
- Research design and methodology
- Findings & Analysis
- Conclusion

References

Annexure

Abbreviations

REFERENCES:

1. Agwu, A. E., Ekwueme, J. N., & Anyanwu, A. C. (2008). Adoption of improved agricultural technologies disseminated via radio farmer programme by farmers in Enugu State, Nigeria. African journal of biotechnology, 7(9).
2. Ambali, O. I., Areal, F. J., & Georgantzis, N. (2021). Improved rice technology adoption: The role of spatially dependent risk preference. Agriculture, 11(8), 691.
3. Apostolopoulos, N, Ratten, V, Petropoulos, D, Liargovas, P, Anastasopoulou, E. Agri-food sector and entrepreneurship during the COVID-19 crisis: A systematic literature review and research agenda. Strategic Change. 2021; 30: 159– 167.
4. Bhingardeve, S. D., Tarde, V. J., & Kolgane, B. T. Knowledge and Adoption of Intercrop in Sugarcane from Kolhapur District. (2018)
5. Bhushan, S. An Overview of Systems Perspective and Modeling in Business Decision Making: A Novel SDBM Approach. (May 2019)
6. Bordonal, R. D. O., Carvalho, J. L. N., Lal, R., de Figueiredo, E. B., de Oliveira, B. G., & La Scala, N. (2018). Sustainability of sugarcane production in Brazil. A review. Agronomy for Sustainable Development, 38(2), 1-23.
7. Chand, R., Joshi, P., & Khadka, S. (2022). Indian Agriculture Towards 2030: Pathways for Enhancing Farmers' Income, Nutritional Security and Sustainable Food and Farm Systems.
8. Curry, G. N., Nake, S., Koczberski, G., Oswald, M., Rafflegeau, S., Lummani, J., ... & Nailina, R. (2021). Disruptive innovation in agriculture: Socio-cultural factors in technology adoption in the developing world. Journal of Rural Studies, 88, 422-431.
9. Dadi, V., Nikhil, S. R., Mor, R. S., Agarwal, T., & Arora, S. (2021). Agri-food 4.0 and innovations: Revamping the supply chain operations. Production Engineering Archives, 27(2), 75-89.
10. Dhande, Nishikant & Salkute, Vijaykumar. (2012). Supply Chain Management in Sugar Industry: A study of Western Maharashtra in India. IJCRR International Journal of Current Research and Review ISSN: 2231-2196. 4. 66-70

11. Fanelli, Rosa. (2021). Barriers to Adopting New Technologies within Rural Small and Medium Enterprises (SMEs). Social Sciences. 10. 10.3390/socsci10110430.
12. Geetha, P., Sivaraman, K., Tayade, A. S., & Dhanapal, R. (2015). Sugarcane based intercropping system and its effect on cane yield. Journal of Sugarcane Research, 5(2), 1-10.
13. Gunawan, E., Ilham, N., Syukur, M., Pasaribu, S. M., & Suhartini, S. H. (2021, November). Farmers' perceptions and issue of Kredit Usaha Rakyat in Indonesia. In *IOP* Conference Series: Earth and Environmental Science (Vol. 892, No. 1, p. 012017). IOP Publishing.
14. Hall, A. (2006). Public-private sector partnerships in an agricultural system of innovation: concepts and challenges. International Journal of Technology Management & Sustainable Development, 5(1), 3-20.
15. Hasan, S., Smart, J. C., Hay, R., & Rundle-Thiele, S. (2021). Changing fertilizer management practices in sugarcane production: cane grower survey insights. Land, 10(2), 98.
16. Hermans, F., Stuiver, M., Beers, P. J., & Kok, K. (2013). The distribution of roles and functions for upscaling and outscaling innovations in agricultural innovation systems. Agricultural Systems, 115, 117-128
17. Hoque, M. J., Hossain, M. I., Sarker, M. A., & Mithun, M. N. A. S. (2021). Problem confrontation of sugarcane farmers in Natore district of Bangladesh. International Journal of Agricultural Research, Innovation and Technology, 11(1), 101-108.
18. Joshi, S., Singh, R. K., & Sharma, M. (2020). Sustainable agri-food supply chain practices: Few empirical evidence from a developing economy. Global Business Review, 0972150920907014.
19. Karpagam, C., Selvam, M. K., & Mooventhan, P. (2019). Technology mapping and adoption behaviour for sugarcane protection technologies by Dharmapuri District Sugarcane growers. Journal of Applied and Natural Science, 11(4), 806-809.
20. Macours, K. (2019). Farmers' demand and the traits and diffusion of agricultural innovations in developing countries. Annual Review of Resource Economics, 11, 483-499.
21. Mehta, C. & Chandel, Narendra & Jena, Prakash & Jha, Anamika. (2019). Indian Agriculture Counting on Farm Mechanization. Ama, Agricultural Mechanization in Asia, Africa & Latin America. 50. 84-89.

22. Miemczyk, J., Carbone, V., & Howard, M. (2022). Learning to Implement the Circular Economy in the Agri-food Sector: A Multilevel Perspective. In Circular Economy Supply Chains: From Chains to Systems. Emerald Publishing Limited
23. Mukherjee Atri, Bajaj Priyanka, Kumar Rishabh and Sebastian Jobin - Department of Economic and Policy Research, RBI Bulletin – (2022), Indian Agriculture: Achievements and Challenges.
24. Oliveira, B. R., Carvalho, J. L. N., Lal, R., Figueiredo, E. B., Oliveira, B. G., & Scala, N. (2018). Sustainability of sugarcane production in Brazil. A review. Agron Sustain Dev, 38(2), 13.
25. Oltra-Mestre, M. J., Hargaden, V., Coughlan, P., & Segura-García del Río, B. (2021). Innovation in the Agri-Food sector: Exploiting opportunities for Industry 4.0. Creativity and Innovation Management, 30(1), 198-210.
26. Peres, R., Muller, E., & Mahajan, V. (2010). Innovation diffusion and new product growth models: A critical review and research directions. International journal of research in marketing, 27(2), 91-106.
27. Quintane, E., Casselman, R. M., Reiche, B. S., & Nylund, P. A. (2011). Innovation as a knowledge-based outcome. Journal of knowledge management.
28. Rahman, M. M., Ali, M. R., Oliver, M. M. H., Hanif, M. A., Uddin, M. Z., Saha, K. K., ... & Moniruzzaman, M. (2021). Farm mechanization in Bangladesh: A review of the status, roles, policy, and potentials. Journal of Agriculture and Food Research, 6, 100225.
29. Richardson, J. W. (2011). Challenges of adopting the use of technology in less developed countries: The case of Cambodia. Comparative Education Review, 55(1), 008-029.
30. Schenkel, M. T., Finley, J., & Chumney, W. (2012). RHS, Inc.: innovation “guiding” agriculture. Entrepreneurship Theory and Practice, 36(2), 415-428.
31. Seghieri, J., Brouwers, J., Bidou, J. E., Ingram, V., Droy, I., Bastide, B., & Sanogo, D. (2021). Research and development challenges in scaling innovation: a case study of the LEAP-Agri RAMSES II project. Agroforestry Systems, 95(7), 1371-1382.
32. Singh, A., Kumar, A., Yadav, R. K., Dutta, A., & Sharma, D. K. (2016). Growth and mineral nutrition in salt stressed guava (Psidium guajava L. cv. Allahabad Safeda). Journal of AgriSearch, 3(1), 21-25.

33. Singh, P., Singh, S. N., Tiwari, A. K., Pathak, S. K., Singh, A. K., Srivastava, S., & Mohan, N. (2019). Integration of sugarcane production technologies for enhanced cane and sugar productivity targeting to increase farmers' income: strategies and prospects. 3 Biotech, 9(2), 1-15.
34. Sugarex Indonesia 2022, Sugar Asia Magazine 2022, Sugar Ex Indonesia, (2022)
35. Sundaram, P. K., Sarkar, B., Raghav, D. K., Kumar, U., Anurag, A. P., & Mali, S. S. (2019). Constraints in adoption of Modern Farm Machines by Tribal Farmers in Ramgarh District of Jharkhand: Constraints in adoption of Modern Farm Machines by Tribal Farmers. *Journal of AgriSearch*, *6*(3), 146-149.
36. Vidmar, M. (2021). Enablers, Equippers, Shapers, and Movers: A typology of innovation intermediaries' interventions and the development of an emergent innovation system. Acta Astronautica, 179, 280-289.
37. Wakchaure, G. C., Pradhan, A., Choudhary, R. L., Meena, K. K., Singh, Y., Biswas, A. K., & Pathak, H. (2021). Conservation Agriculture for Enhancing Productivity, Resource Use Efficiency and Environmental Quality of Sugarcane Cropping System. Technical Bulletin, (33), 40.
38. Weerabahu, S. K., Samaranayake, P., Dasanayaka, S. S., & Wickramasinghe, C. N. (2021). Challenges of agri-food supply in city region food systems: an emerging economy perspective. Journal of Agribusiness in Developing and Emerging Economies.
39. Wiedmaier, B. (2017). Post hoc tests. M. Allen, The SAGE Encyclopedia of Communication Research Methods, 3.
40. Wongwai, K., Kamarulzaman, N. H., Seng, K. W. K., & Ali, F. FACTORS INFLUENCING SMALL FARMERS TO PARTICIPATE IN SUGARCANE LOADING STATIONS IN THAILAND.
41. Yang, L., Zhou, Y., Meng, B., Li, H., Zhan, J., Xiong, H., Zhao, H., Cong, W., Wang, X., Zhang, W., Lakshmanan, P., Deng, Y., Shi, X., Chen, X., & Zhang, F. (2022). Reconciling productivity, profitability and sustainability of small-holder sugarcane farms: A combined life cycle and data envelopment analysis. *Agricultural Systems*.

42. Zulu, N. S., Sibanda, M., & Tlali, B. S. (2019). Factors affecting sugarcane production by small-scale growers in Ndwedwe Local Municipality, South Africa. Agriculture, 9(8), 170.

WEBSITES:

1. https://iisr.icar.gov.in/iisr/pages/prod.jsp
2. https://methods.sagepub.com/reference/the-sage-encyclopedia-of-communication-research-methods/i4910.xml
3. https://www.intechopen.com/chapters/49176
4. https://economictimes.indiatimes.com/news/economy/agriculture/sugarcane-production-in-maharashtra-may-go-up-by-over-200-lakh-tonnes-nfcsf-chief/articleshow/84172180.cms?from=mdr
5. https://www.jstor.org/stable/255139
6. https://www.financialexpress.com/market/maharashtra-beats-up-with-record-sugar-production-this-season/2467200/#:~:text=Maharashtra%20is%20looking%20at%20record,111.16%20lakh%20tonne%20of%20sugar.
7. https://www.sarkaritel.com/sugar-production-for-2021-22-expected-to-be-114-lmt-in-up/
8. https://methods.sagepub.com/reference/the-sage-encyclopedia-of-communication-research-methods/i4910.xml
9. https://timesofindia.indiatimes.com/city/coimbatore/sugarcane-farmers-told-to-adopt-new-tech-for-sweet-future/articleshow/65536425.cms
10. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6346606/
11. (http://www.krishijagran.com/news/government-seven-point-strategy-for-doubling-farmers-income/&hl=en-IN)
12. https://www.fao.org/3/CA2460EN/ca2460en.pdf
13. https://en.wikipedia.org/wiki/Uddhab_Bharali
14. https://digest.myhq.in/social-entrepreneurs-in-india/
15. https://www.freshconsulting.com/insights/blog/what-is-innovation/
16. https://solvinnov.com/what-is-innovation/

17. https://www.oecd.org/agriculture/topics/agricultural-productivity-and-innovation/
18. https://innovatemap.com/resource/four-urgent-challenges-facing-tech-innovation-in-agriculture/)
19. https://research.wur.nl/en/publications/innovation-platforms-synopsis-of-innovation-platforms-in-agricult
20. https://ec.europa.eu/eip/agriculture/en/what-innovation
21. https://www.fao.org/3/CA2460EN/ca2460en.pdf
22. https://www.umsl.edu/~sauterv/analysis/F2015/Soft%20Systems%20Methodology.html.htm
23. http://www.agritech.tnau.ac.in/expert_system/sugar/harvesting.html
24. http://www.bajajhindusthan.com/procurement-process.php#:~:text=After%20receiving%20the%20purchy%2C%20the,through%20rail%20to%20the%20mill.
25. https://dfpd.gov.in/sugar-sugarcane-policy.htm
26. .https://www.forbes.com/sites/angelicamarideoliveira/2018/10/27/worlds-largest-sugarcane-producer-ignites-innovation-for-bioenergy-generation/?sh=29c3245b4e2e
27. http://www.krishijagran.com/news/government-seven-point-strategy-for-doubling-farmers-income/&hl=en-IN

ANNEXURES:

Data Collection during Pilot Study from Maharashtra and Uttar Pradesh's Sugar Mill

Abbreviations

- OECD: The organisation for Economic Co-operation and Development
- EIP Agri – European Commission: The agricultural European Innovation Partnership (EIP-AGRI)
- FAO: Food and Agricultural Organization
- BRICS countries: The Federative Republic of Brazil, The Russian Federation, The Republic of India, The People's Republic of China, and The Republic of South Africa
- NABARD: National Bank for Agriculture and Rural Development
- ISMA: the Indian Sugar Mills Association
- SMAM: Sub-Mission on Agricultural Mechanization